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ABSTRACT

This paper presents an approach for developing flexible Hypermedia Learning Environments (HMLE) and applies this theoretical framework to the creation of a layered model of a hypermedia system, called HyperDisc, developed at the German Institute for Research on Distance Education. The first section introduces HMLE and suggests that existing hypermedia systems often suffer from theoretical, conceptual, and methodological shortcomings. The empirical background of hypermedia use and hypertext-based technologies are discussed in the second section. The next section deals with design features crucial for flexible HMLE, following a model for describing computer-based systems that comprises learner, subject matter, pedagogic-didactic, and information technology components. The fourth section presents the HyperDisc program as a prototype of HMLE intended to cope with design requirements outlined for fostering open and flexible learning; features discussed include expository learning activities, exploratory learning activities, expressive learning activities, and openness (i.e., the potential to integrate and create new contents). A figure illustrates the main screen of HyperDisc. Contains 14 references. (DLS)

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# Teaching and Learning with Flexible Hypermedia Learning Environments

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**Abstract:** Hypermedia systems may be used for different purposes. However, in order to be used for teaching and learning purposes they have to be designed in a comprehensive manner taking into consideration features considered as crucial for flexible HMLE. In outlining these features we will follow a conceptual model for describing computer-based systems. We then present our approach to apply this theoretical framework and to create a layered model of an hypermedia system, called HyperDisc, which served as a guideline for further conception and development activities.

## 1. Introduction

In information society lifelong learning is essential. People of all ages have to cope with an ever increasing complexity of subject matters as well as multiple formats of subject-matter representations. There is a need for just-in-time self-regulated, open and flexible access to world-wide distributed information as well as the need for flexible use of this information according to the individual´s own study interests. Thus open and flexible teaching/learning environments as well as subject-matter representations which may support individual study interests effectively are becoming more and more important. Hypermedia Learning Environments (HMLE) are attributed to have a great potential in fullfilling the above mentioned requirements.

A review of empirical studies shows, that initial optimistic views on the efficacy of HMLE have to give way to a more realistic view [Rouet 1992]. Several other reviews revealed that existing hypermedia systems as well as empirical research often suffer from theoretical, conceptual and methodological shortcomings [Tergan 1997 a,b,c]. It is claimed that in many cases hypermedia environments have not been designed and used appropriately to foster learning. This is why Jacobsen [Jacobsen 1994] and Tergan [Tergan 1998] strongly argue for a closer link of theory to design, research and application in real instructional settings.

In the present paper some of the problems mentioned are addressed. In the first part the empirical background is discussed. Deficiencies of existing systems are outlined briefly. The second part deals with requirements for the design of HMLE. In the third part of the paper we present our program HyperDisc as an example of a HMLE which has been developed at the German Institute for Research on Distance Education as a prototype to cope with design requirements outlined for fostering open and flexible learning.

## 2. Empirical background

The first ten years of hypermedia use and research have been inspired by some basic expectations and theoretical assumptions concerning the global efficacy of these systems in promoting knowledge acquisition and information retrieval. For example, some researchers have argued that basic structural and functional features of hypertext/hypermedia-technology match very well with cognitive network theories of the human mind, constructivist principles of learning and multiple mental modes for representation of knowledge. The assumptions draw back on the potential of hypertext/hypermedia to represent subject-matter content in a non-linear fashion, to enable flexible information access and self-regulated learning, and to represent a subject matter from different views and in different symbol systems.

The suggested match has nourished expectations that hypertext-based technologies may overcome deficiencies inherent in the traditional reading comprehension and information processing approach of teaching and learning and may even revolutionize learning [Jonassen 1986, Landow 1990]. It has been claimed that

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hypermedia technology may overcome some of the limitations of the traditional database approach for information retrieval [Marchionini 1995].

Meanwhile the initial enthusiasm concerning the potential of hypermedia for promoting learning has given way to a more realistic view. Reviews concerning the empirical evidence of the suggested potential of hypermedia for fostering learning and information retrieval have revealed both disappointing and encouraging results [e.g. Rouet 1992]. The results indicate that learning based on hypertext and hypermedia on the one hand may lead to navigational and conceptual disorientation and is often less effective then learning with traditional media, as is shown in comparative studies [e.g. Gordon et al. 1988]. On the other hand the results indicate that learning with hypermedia may contribute to enhance learning and contribute to cognitive flexibility when the learning environment is designed taskappropriately and when it is used by learners with appropriate learning competencies in a flexible manner [Spiro et al. 1991, Rouet 1992].

Tergan [1997 a,b,c] has analysed the theoretical, instructional and methodological conditions which may be of relevance for explaining failures and successes in using (capitalizing on) the potentials of hypermedia for enhancing learning. His review on the validity of theoretical assumptions concerning the global efficiency of hypertext/hypermedia supports the suggestion that the theoretical rationale of most of the approaches has been primarily led by technology-based enthusiasm on the potential of hypertext/hypermedia to enable and support learning [see also Spiro et al. 1991]. From an instructional design point of view it is criticized that the rationales for hypertext/hypermedia design have not always been tailored taskadequately and have disregarded conditions of effective learning in instructional contexts [Tergan 1997 b]. It is claimed that because of the inadequate tailoring of hypertext/hypermedia design and an inappropriate match between the inherent potential of a system to support certain learning functions and the criteria used for assessing learning effectiveness, the potential of certain types of systems for supporting particular aspects of learning may have been underestimated.

Tergan [1997c] draws attention to empirical results and the central claim of cognitive psychology that effectivity of learning with the help of a technology is the result of a complex interaction of constraining conditions on the side of the learner (e.g. level of learning, study interests, motivation), instructional methods to support learners in task appropriate processing (e.g. modeling, coaching, scaffolding), attributes of the learning material (structure, complexity, formats of representation) and the media used (e.g. interactivity, accessability of information elements, potential for multiple coding formats). It also depends on situational constraints like authenticity of the learning situation, embeddedness in an overall instructional approach, etc.

## 3. Design features

Hypermedia systems may be used for different purposes. However, in order to be used for teaching and learning purposes they have to be designed in a comprehensive manner taking into consideration features considered as crucial for flexible HMLE. In outlining these features we will follow a conceptual model for describing computer-based systems [Tergan, Mandl and Hron 1992]. Basic components of this model are the learner component, the subject matter component, the pedagogic-didactic component, and the information technology component.

### 3.1 Learner component

All learners do have their individual characteristics concerning motivation, cognitive abilities, and preknowledge, which have to be taken into consideration. Such an important factor is the learning strategy. Three main types of learning strategies in hypermedia-systems are postulated for improving learning [Astleitner and Leutner 1995], based on results in an exploratory study in which three component processes were identified (attaining a temporarily activated goal, ensuring spatial orientation, aquiring knowledge). The authors differentiate these further into eleven substrategies (i.e. use filtering, neighborhood exploration, and zooming as general methods for successful goal attainment; use nodes with landmark-quality for better orientation).

In spite of the lack of empirical data on the effect of these strategies on "learning" with hypermedia, it seems most important to offer a wide range of orientation and navigation features, in order to support most of the

conceivable strategies and to give the learners a real choice. Within the learning process the learners thus can be encouraged to change their strategies, according to task and training.

### 3.2 Subject matter component

Subject matters are not only increasingly complex but also change rapidly in many fields. HMLE, dealing with such complex subject matter and providing for flexibility in learning topics and extensive contents, have to be open for continuing completion and updating. This presupposes an open structure, allowing successive addition of new nodes and links. By now, this may be accomplished - at least to some extent - by directly accessing the WorldWideWeb, which has hypertextual elements itself. In the same manner application programs can be linked to the HMLE, thus enabling the learners to apply newly aquired (procedural) knowledge in real tasks with common tools.

Nonlinear use of the material should be stimulated by optional visits of nodes with additional information. They can be made available to the learners by filters or tours, thus highlighting different aspects and enabling different approaches. The relevance of the nodes within special filters or tours should be elucidated with annotations.

### 3.3 Pedagogic-didactic component

There are roughly three modes in which information technology resources can be used in teaching and learning:

*Expository learning activities* involve the learners in working through information presented at an appropriate level by a teacher.
*Exploratory learning activities* involve the learners in exploring ideas about a topic presented by someone else (teacher or expert), where the ideas may often be quite different from the learner´s ideas.
*Expressive learning activities* involve the learners in expressing their own ideas [Mellar et al. 1994].

In many situations these modes can overlap. As Mellar et al. point out in the case of simulation and modelling, it is possible to use the respective tools both in an exploratory and expressive mode of learning. With appropriate design features, we think HLMEs now can support all three modes, thus giving teachers and learners maximum flexibility. The different modes of using HMLE all depend on easy and successful orientation and navigation within the information base. It is therefore crucial that the structure of the material is made explicit, using textual or graphical browsers to visualize the individual learning path, the result of a query, the context of the present location etc.

### 3.4 Information technology component

As HMLE cannot be designed for a limited group with precisely described cognitive abilities - not least due to economic reasons - we need HMLE which are adaptable to various target groups and which allow the application of different learning strategies, thus optimizing the development efforts [Valcke and Vuist 1995). These requirements have repercussion even on the architecture of such systems and must be taken into consideration in all phases of development.

Our prototypical HMLE HyperDisc demonstrates the close relationship between the results of an extensive analysis of the conceptual model components and our design decisions concerning the structuring the information base, representation, layout and screen design, the integration of additional materials, help functions and communication tools. In the following we can only exemplify this with the support functions for expository, exploratory and expressive learning activities.

## 4. HyperDisc - a prototypical flexible HMLE

### 4.1 Expository learning activities

The contents within HyperDisc can be structured to support the different prerequisites, preferences and goals of the users. A critical factor is the user with little prior knowledge and little HMLE experience in general with the need for particular support. In this case expository adaptation of the content is a central approach which is implemented by arranging a subset of pages sequentially. HyperDisc covers three types of sequences:

*Standard Tour:* This tool is made for beginners and allows them a fast overview of the content. The most important pages are collected, annotated and presented as an item list.
*Extra Tours:* Authors may compile many annotated sequences to condense subjects or reorganise them in their sequences. Implicit connections can be made more explicit.
*Sequenced hierarchy:* Whereas standard tour and extra tours are excerpts of the content hierarchy here all pages can be read one after the other.

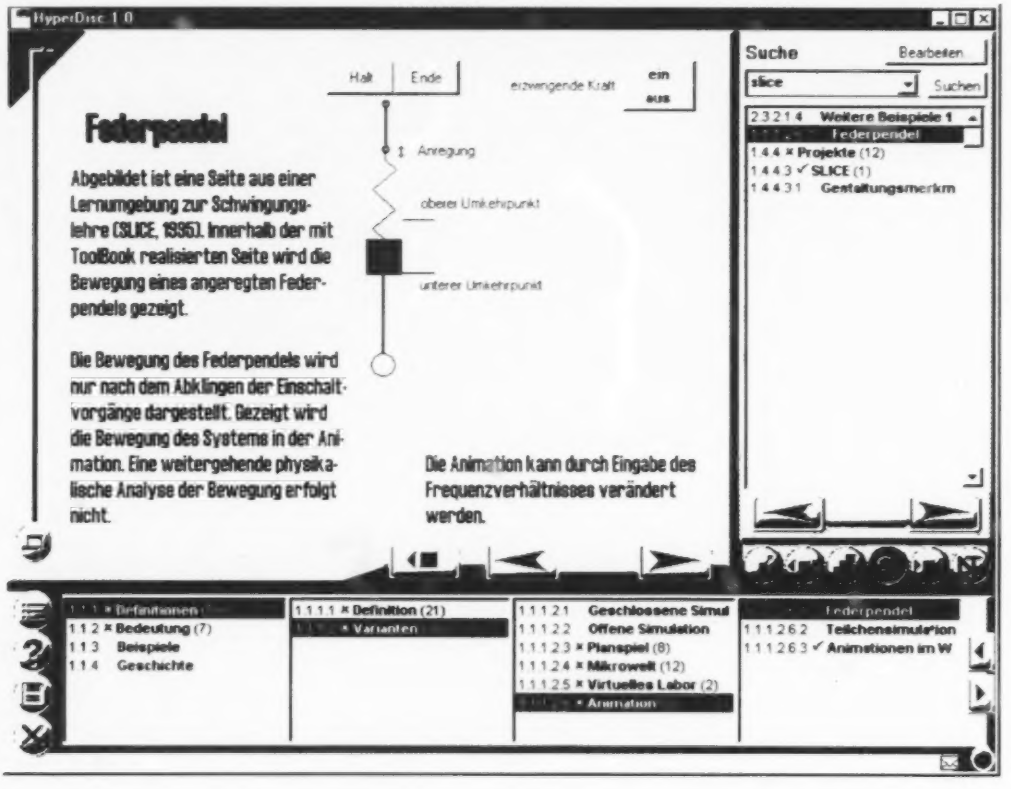
HyperDisc 1.0
Halt
Ende
erzwingende Kraft
ein
aus
Federpendel
Anregung
oberer Umkehrpunkt
unterer Umkehrpunkt
Abgebildet ist eine Seite aus einer Lernumgebung zur Schwingungslehre (SLICE, 1995). Innerhalb der mit ToolBook realisierten Seite wird die Bewegung eines angeregten Federpendels gezeigt.
Die Bewegung des Federpendels wird nur nach dem Abklingen der Einschaltvorgänge dargestellt. Gezeigt wird die Bewegung des Systems in der Animation. Eine weitergehende physikalische Analyse der Bewegung erfolgt nicht.
Die Animation kann durch Eingabe des Frequenzverhältnisses verändert werden.
Suche
Bearbeiten
slice
Suchen
2 3 2 1 4 Weitere Beispiele 1
Federpendel
1 4 4 × Projekte (12)
1 4 4 3 ✓ SLICE (1)
1 4 4 3 1 Gestaltungsmerkm
1 1 2 × Bedeutung (7)
1 1 3 Beispiele
1 1 4 Geschichte
1 1 1 1 × Definition (21)
1 1 1 2 1 Geschlossene Simul
1 1 1 2 2 Offene Simulation
1 1 1 2 3 × Planspiel (8)
1 1 1 2 4 × Mikrowelt (12)
1 1 1 2 5 × Virtuelles Labor (2)
1 1 1 2 6 2 Teilchensimulation
1 1 1 2 6 3 ✓ Animationen im W

**Figure 1:** Main screen of HyperDisc. On the upper left is the presentation of the learning material (the example is taken from the chapter on simulation, describing the interactive animation of a pendulum). On the right the tools, which can be switched: tours, history, bookmarks and the search utility (currently shown). Below the hierarcical browser, showing the context of the page.

### 4.2 Exploratory learning activities

Of course users may deviate from the tours at any time and e.g. switch to a more explorative mode of learning. Four types of structure, respectively tools, are offered for this case:

*Hierarchy:* All available pages are arranged hierarchically and are represented in first-order fisheye view in the browser.



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*Hyperlinks:* Located within the text body and popups.
*Cross-references:* Optionally shown in a seperate menu.
*Search:* An easy-to-use fulltext search system in which index terms can be used.
*History:* Running automativcally over subsequent sessions.
*Filters:* Lists of highlighted pages according to the objective (without having to work through them in a certain sequence).

In order to support self-regulated flexible access to information, information seeking and the associated navigational strategies browsing and searching [Marchionini 1995] play an important role. Existing HMLE present both features without integrating them closely in the manner of Marchionini. However, this integration seems to be most relevant because these processes complement each other, altering permanently and unpredictably due to the changing knowledge and goals of the user during the localisation and learning activities.

As a consequence, corresponding tools and structure representations may be used parallel in HyperDisc on the one hand and on the other hand search results are integrated into all link anchors across the system by displaying different colors and little icons (small hooks and crosses). A particular status within this procedure is ascribed to the browser which allows the restriction of the search results using the hierarchical structure. On the other side, beginning with a single found item, its context may be re-established leading to a quick assessment of its relevance.

This principle of structural overlapping is applicable to all linear structures in HyperDisc, e.g. an extra tour may be used for filtering the hierarchy. This procedure is implemented consistently across the system and allows for drilling down information effectively .

### 4.3 Expressive learning activities

These learning activities - either performed in parallel or following explorative behaviors - will be supported by:

*Bookmark and annotation facilities:* According to the rationale of tours, the bookmark-function allows for gathering information and annotations according to definable categories.
*Restructuring facilities:* Advanced users may switch into the authoring mode in order to reorganize the hypermedia basis for individual needs, e.g. adding links, building up alternative hierarchies (multitrees) designing an individual tour.
*Creating and integrating new contents:* With the help of an extra editor new content nodes of ToolBook-pages may be generated and implemented into the database of the HyperDisc. In a similar way the links to the WWW may be supplemented.

### 4.4. Openness

The possibility to integrate and create new contents shows the openness of HyperDisc in terms of subject-matter content. This openness is realized technically by distinguishing three components: the content-nodes, the structure of content and the integrating shell itself. All components may be altered independently. Content-nodes in the authoring mode can be generated by providing the users with a standard Toolbook utility. Thus content nodes as well as multimedia components and external programs can be supplemented with contents of WWW-pages, which may be accessed on-line.

## 5. Perspectives

HyperDisc can be used to incorporate any topic for hypertextual and multimedia presentation. Our first application is training material for students, decision makers and developers in the field of new educational media. At present HyperDisc Version 1.0 is available, including parts on "Simulation and Modelling" and

"Hypertext/Hypermedia". Additional parts are planned. These versions will be available in 1998 as well as several tools to develop the HyperDisc-applications.

HyperDisc serves as material for our research. We will evaluate the use of Version 1.0 in a distance education course "New Educational Media", run by the Fachhochschule Furtwangen in 1997/98. Evaluative results will be available in mid 1998. In addition we are planning controlled experiments with variants of HyperDisc to investigate the use of different navigational tools in problem solving situations.

Additional information on concept, implementation and availability of HyperDisc can be found at: *http://www.uni-tuebingen.de/uni/dii/A1/hyperdisc/besch/s2.htm*

Comments and critiques are welcome in our discussion forum at: *news://news.diff.uni-tuebingen.de/hyperdisc.**

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